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11 Investment, Financial Factors, and Cash Flow: Evidence from U.K. Panel Data

Michael Devereux and Fabio Schiantarelli

11.1 Introduction

Most empirical models of company investment rely on the assumption of perfect capital markets. One implication of this assumption is that, in a world without taxes, firms are indifferent to funding their investment programs from internal or external funds. However, there is a rapidly growing body of literature examining the possible existence of imperfections in capital markets and their effects on firms' financial and real decisions. In this paper we provide some econometric evidence on the impact of financial factors like cash flow, debt, and stock measures of liquidity on the investment decisions of U.K. firms. These variables are introduced via an extension of the Q model of investment, which explicitly includes agency costs. We discuss whether the significance of cash flow is due to the fact that it proxies for output or because it is a better measure of market fundamentals than Q. Moreover, we investigate if the effect of financial factors varies across different types of firm. The cross-sectional variation of the impact on investment of flow and stock measures of liquidity has been analyzed also by Fazzari, Hubbard, and Petersen (1988) and by Gertler and Hubbard (1988) for U.S. firms and by Hoshi, Kashyap, and Scharfstein (1988) for Japanese firms. The former studies distinguish between firms according to their dividend payment behavior, while the latter

Michael Devereux is director of the Corporate Sector Research Programme at the Institute for Fiscal Studies, London. Fabio Schiantarelli is associate professor at Boston University and research associate at the Institute for Fiscal Studies.

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classifies firms according to the strength of their institutional relationships with banks. Instead, we group observations according to firm size. age. and type of industry (growing and declining). The empirical importance of this breakdown is a natural subject of investigation and moreover allows us to minimize the problems of endogenous selection. In the theoretical section we outline a simple model that illustrates how cash flow can be introduced in Q models. We discuss the determinants of the size of the cash-flow effect and explain why caution must be exercised in attributing interfirm differences only to differences in the importance of agency or financial distress costs.

In Section 11.2 we briefly review recent contributions to the literature on credit market imperfections, and in Section 11.3 we show how features appearing in these models might be expected to influence investment decisions. Section 11.4 develops a simple extension of the investment model with adjustment costs that explicitly allows for agency costs of extemal finance. Section 11.5 describes the behavior and performance of a sample of 720 manufacturing firms in the United Kingdom. split by size and age. and Section 11.6 presents some econometric results, obtained using instrumental variables, which indicate that financial factors. principally in the form of lagged cash flow. do have an independent effect on investment. Section 11.7 is a brief conclusion.

11.2 The Cost of External Finance

During the last few years there has been a renewed interest in understanding the relationship between investment and financing decisions. at both the theoretical and empirical levels. The common theme underlying the various contributions is the lack of perfect substitutability between inside and outside financing. The existence of differential information and incentive problems makes extemal finance more costly than intemal finance. In this setting the availability of intemally generated funds. and/or of assets that can be used as collateral, may have an effect on investment decisions.

Let us briefly review the disadvantages and benefits of extemal finance. Starting with debt finance. there are different reasons why there may be a conflict between shareholders and debtholders. giving rise to agency costs of debt. Jensen and Meckling (1976) suggest that stockholders will have an incentive to engage in projects that are too risky and so increase the possibility of financial distress and bankruptcy. If successful, the payoff to the owners of the firm is large. If unsuccessful, the limited liability provision of debt contracts implies that the creditors bear most of the cost. Myers (1977) suggests that if the firm is partly debt financed, it may underinvest in the sense that it forgoes projects with a positive net present value. This problem is particularly severe when assets in place are a small proportion of the total value of the firm. Other areas of conflict between bondholders and shareholders are represented by the claim dilution resulting from the issue of additional debt and by the possibility that the firm may pay out excessive dividends financed by reduced investment.

Since potential creditors are assumed to understand the incentives facing stockholders and are aware of the risk of bankruptcy when loans are negotiated, the owner will ultimately bear the consequences of these agency problems in terms of a higher cost of debt. With asymmetric information about borrower quality, rationing may also occur (see Jaffee and Russell 1976; Stiglitz and Weiss 1981). As a way to control the conflict between bondholders and shareholders and to minimize the agency cost of debt, bond covenants are observed, limiting the discretionary action of the owners regarding dividends, future debt issues, and maintenance of working capital (Smith and Warner 1979). Debt covenants usually contain a maximum limit on the amount of dividends that can be paid out that depends positively upon accumulated earnings. Restrictions on the minimum value of the ratio between tangible assets and debt, working capital and debt and, finally, between interest payments and cash flow are also common. The greater is the amount of debt in the firm's capital structure, the more severe the incentive problems become, and the more likely it is that the firm will face financial distress and ultimately bankruptcy. Because of the less favorable terms on which debt can be obtained and because of the cost associated with tighter monitoring and bonding activities, agency costs are therefore likely to be increasing in the level of debt. On the other hand, it is likely that such costs are a decreasing function of the level of past and present earnings and of assets, particularly if liquid in nature, that can be used as collateral.

While agency costs make debt less attractive, the tax deductibility of interest payments makes it more attractive. In the absence of such costs, debt is preferred to retentions if $(1 - m)/(1 - z) > 1 - \tau$, where m is the marginal personal tax rate on interest income, z the tax rate on capital gains, and τ the corporate tax rate (King 1977). In the United Kingdom this inequality is satisfied for most investors.[1]

New share issues may be disadvantageous because of transaction costs, tax reasons, or asymmetric information. Informal evidence on transaction costs in the United Kingdom suggests that there are large fixed costs in issuing new equity.[2] The tax disadvantage of new share issues relative to retentions in a classical system of company taxation depends upon the relationship between personal tax rates on dividends, m, and capital gains, z. If m is greater than z, as is usually the case, new equity issues are relatively more expensive (see, e.g., King 1977). In an imputation system, like the one in existence in the United Kingdom since 1973, the situation is more complex. New share issues are a cheaper source of finance for a full tax paying firm if $(1 - m)/[(1 - z)(1 - c)] > 1$, where c is the rate of imputation. This condition will be satisfied for institutional investors for whom $m = z = 0$ and for other investors with a low marginal tax rate on dividends.[3]

Finally, new share issues may be more costly because of asymmetric information. Myers and Majluf (1984) suggest that, if managers have inside information, it may happen that that information is so favorable that management, acting in the interest of old shareholders, will not issue new shares, which are perceived as being underpriced. Investors will therefore interpret the decision to issue new shares as a bad signal. In this case, new equity finance can only be obtained at a premium because of the adverse selection problem.

Up to this point in the discussion we have implicitly assumed that management acts in the interest of shareholders. Allowing for the possible divergence of interest between managers and outside shareholders provides an additional rationale for the disadvantage of external finance. If managers have a less than 100% ownership stake in the company, they will be encouraged to use a greater than optimal amount of the firm's resources in the form of perquisites (Jensen and Meckling 1976). Such activities can be monitored by the outside shareholders, but such monitoring is costly, and the insiders will ultimately bear the cost in terms of a reduced price that prospective outside shareholders are willing to pay for a stake in the firm. This consideration suggests that the cost of outside financing is related to the stake of insiders and to the dispersion of outside ownership.

11.3 Financial Factors and Investment Decisions

What is the effect of credit availability, cash flow, and collateralizable assets on investment decisions? The literature on this issue has been conducted in the context of models with different structures concerning information and technology. One group of papers adds financial considerations to standard investment models based on the assumption of convex adjustment costs, usually estimated in their Q form. For example, credit rationing with an exogenously given ceiling can be easily added to Q models. If there are tax advantages to debt, firms will borrow up to capacity. Under the standard assumptions (perfect competition, constant returns to scale, a single quasi-fixed factor), marginal Q will continue to equal average Q, with the caveat that the present value of the interest payments net of new debt issued should be added to the market value of shares in defining average Q. The present value of these flows can be approximated by the current value of the stock of debt. One could also assume that the maximum amount of debt is a fixed proportion of the capital stock (Summers 1981) with basically the same result.

Alternatively one could include in the objective function an additional cost term, increasing in the level of debt, that summarizes the agency/financial distress cost of debt, as in Chirinko (1987).[4] In this case, an internal solution for debt can be obtained. If the agency cost of debt is linear homogeneous in its arguments, and the change (as opposed to the level) of debt does not enter the agency cost function, marginal Q again equals average Q. If the change in debt does appear in the agency cost function and the latter is not linear homogeneous, the difference between marginal and average Q depends upon the present and future values of the change and level of debt (Chirinko 1987).

When personal taxation is taken into account, and if capital gains are taxed less heavily than dividends, one can distinguish between three financing regimes.[5] In regime 1, investment can be financed at the margin by retentions, positive dividends are paid, and no new shares are issued. In regime 3, the firm issues new shares and pays no dividend. In the intermediate case, regime 2, both dividends and new share issues are zero and the marginal source of finance is debt. A relationship between investment and tax-adjusted average Q can be derived only in regimes 1 and 3. In regime 2 no such relationship exists, and investment equals cash flow plus new debt issued. In this context, an increase in cash flow makes the probability that investment is financed at the margin by retentions more likely, and this can be shown to increase investment (Hayashi 1985). However, conditional on Q, cash flow does not have an additional explanatory power in regimes 1 and 3. In regime 2, increases in cash flow (and debt) translate into a one-to-one increase in investment and Q does not matter.

Fazzari, Hubbard, and Petersen (1988) extend Q models by including a premium for issuing new shares, based on the adverse selection argument put forward by Myers and Majluf (1984). The existence of this premium increases the cost differential between internal finance and new equity, and it increases the likelihood that the firm will find itself at the point of discontinuity where all profits are retained, no dividends are paid, and the firm's future prospects are not good enough to induce it to issue new shares. For those firms Q does not matter, while cash flow does matter.

In another group of papers the role and consequences for investment of informational imperfections are more closely analyzed. In this context the amount of net assets that can be used as collateral is a determinant of the agency cost of external finance and has an effect on investment. The particular informational asymmetry and the details about technology differ across papers, but the common theme is that insiders have less incentive to cheat and more incentive to act in the interest of outside investors when their stake in the project is greater (see the contributions by Bernanke and Gertler 1989; Gertler 1988; and Gertler and Hubbard 1988). The link between the firm's value and the fraction of entrepreneur wealth invested in the project is also emphasised by Leland and Pyle (1977). Since the borrower's net worth is likely to be procyclical, incentive problems may be particularly severe in a recession. This may lead to an asymmetric effect of financial variables on investment during the business cycle.

The existence of informational asymmetries that restrict the firm's ability to raise external equity plays a crucial role also in the paper by Greenwald and Stiglitz (1988). They show that production and investment depend upon the equity position. Since there is only limited access to equity markets, the main way to change firms' equity is to accumulate cash flow, net of financial obligations. All these models imply that an increase in collateralizable net worth may stimulate investment. The more precise modeling of the informational asymmetries and of the possibility of bankruptcy is clearly a strength of these models. However, they do not yield an investment equation that explains how financial factors and expectations about firms' prospects jointly determine investment.

11.4 From Theory to Testing

The empirical importance of financial variables, in particular cash flow and stock measures of liquid assets, characterizes many econometric studies of investment based on firm-by-firm data (see Fazzari, Hubbard and Petersen 1988, and Gertler and Hubbard 1988 for the United States; Hayashi and Inoue 1988, and Hoshi, Kashyap, and Scharfstein 1988 for Japan; and Blundell et al. 1989 for the United Kingdom). Most of the testing has been conducted in the context of Q models in which average Q is used to control for the investment opportunities open to firms. Fazzari et al. and Gertler and Hubbard analyze the cross-sectional variation in the importance of financial factors by classifying firms according to their dividend payout behavior, while Hoshi et al. make a distinction between firms with and without strong links with a single bank.

We discuss the role of financial factors in the context of a simple variant of a Q model of investment. The model includes on the cost side a term, A, representing agency/financial distress costs which is a function of the stock of debt B, the capital stock K, the stock of liquid assets L, and cash flow X. Debt and liquid assets are chosen endogenously, together with investment and new share issues. On the basis of the arguments of the previous section, agency costs are an increasing function of debt and a decreasing function of cash flow and of liquid assets. The agency cost function is expected to vary for firms in different age and size classes and in different industries. The reasons why this may be the case are summarized in Section 11.5. Moreover there is a premium that must be paid for issuing new shares. This way of summarizing informational asymmetries and the risk of bankruptcy is obviously ad hoc. It is adopted here to provide some unifying principle to our discussion and to our empirical testing and to make clear the implicit assumptions underlying the type of equations that have been used so far to test for the importance of financial factors in equations containing average Q. In particular, we want to specify a model that is consistent with the fact that cash flow may matter (albeit differently) for all firms, and not only for those that have used up all retentions and are not issuing any new shares. Under the assumption of perfect competition and linear homogeneity of the production, adjustment, and agency cost functions, the marginal condition for investment, I, implies that when positive dividends are paid (see Appendix),

$$(1)\qquad \left(\frac{I}{K}\right)_t = \frac{1}{b(1 - A_X)}\left\{\frac{\lambda_t^K/\gamma}{(1 - \tau)p_t^y} - \frac{p_t}{(1 - \tau)p_t^y}\right\},$$

where A_X denotes the partial derivative of the agency cost function with respect to cash flow, λ_t^K is the marginal shadow value of capital, p_t^y the output price, p_t the investment price, all in period t, b is a parameter from the adjustment cost function (defined in the Appendix), τ the corporate tax rate, and γ the tax discrimination parameter between dividends and retentions equal to $(1 - m)/[(1 - z)(1 - c)]$. The linear homogeneity assumption, although not necessarily realistic, allows one to show that the following relationship holds between the marginal and average values of the capital stock:

$$(2)\qquad \lambda_t^K K_{t-1}(1 - \delta) + \lambda_t^B B_t + \lambda_t^L L_t = V_t\left(1 + \frac{R}{1 - z}\right),$$

where V_t is the market value of the firm's shares at the beginning of period t, R is the market return on equity, δ is the depreciation rate, and the λ's are the shadow values of the state variables. If the firm is on its optimal path, it is possible to show that $\lambda_t^B = -(\gamma + \mu_t^D)[1 + R/(1 - z)]$ where μ_t^D is the multiplier on the nonnegativity condition for dividends. Similarly, $\lambda_t^L = (\gamma + \mu_t^D)[1 + R/(1 - z)]$. If positive dividends are paid, as is almost always the case in our sample, the multiplier, μ_t^D, is zero. Using this result in (2) and taking a first-order approximation of (1) around sample averages or steady state values we can write:

$$(3)\qquad \left(\frac{I}{K}\right)_t = \beta_0 + \beta_1 Q_t + \beta_2\left(\frac{X}{pK}\right)_t + \beta_3\left(\frac{B}{pK}\right)_t + \beta_4\left(\frac{L}{pK}\right)_t,$$

where I/K denotes investment expenditures and

$$(4)\qquad Q_t = \frac{(V_t/\gamma + B_t - L_t)\left(1 + \dfrac{R}{1 - z}\right)}{(1 - \delta)K_{t-1}(1 - \tau)p_t^y} - \frac{p_t}{(1 - \tau)p_t^y}.$$

The coefficients, denoting sample averages or steady state values by bars, are:

$$(5)\qquad \beta_1 = \frac{1}{b(1 - \bar{A}_X)};\ \beta_2 = \frac{\overline{\left(\frac{I}{K}\right)}\bar{A}_{X,X/K}}{1 - \bar{A}_X};\ \beta_3 = \frac{\overline{\left(\frac{I}{K}\right)}\bar{A}_{X,B/K}}{1 - \bar{A}_X};\ \beta_4 = \frac{\overline{\left(\frac{I}{K}\right)}\bar{A}_{X,L/K}}{1 - \bar{A}_X}$$

where subscripts again denote partial derivatives.

This equation suggests that the coefficient in front of average Q reflects both the adjustment cost parameter b and the derivative of the agency cost function with respect to cash flow. The coefficient of cash flow is positive if $A_{X,X/K} > 0$, as is reasonable to assume (i.e., increasing cash flow reduces agency costs at a decreasing rate). The coefficient increases with the average investment rate. It also depends upon average cash flow/capital, debt/capital, liquid assets/capital. Similar comments apply to the coefficients of B/K and L/K, the signs of which depend on the cross partial derivatives of A. If the agency cost function is additively separable in the pairs (X,K), (B,K), and (L,K), the last two regressors can be omitted and the coefficient of X/K depends only upon the average cash flow to capital ratio (in addition to the investment rate). Unless more specific assumptions are made about the functional form of A, little can be said a priori on its effect on the size of the coefficient, and this is a source of ambiguity in forecasting the expected strength of the effect of cash flow, debt, and liquid assets on investment for different types of firms. Aside from this ambiguity, we allow the agency cost function to be displaced upward or downward by a multiplicative constant that is specific for each group of firms and therefore varies according to size, age, and sector. An increase in the constant unambiguously increases the coefficients of cash flow, debt, and liquid assets.

There are several reasons why the agency cost function may vary across firms. First, it might be expected that young and small firms may be at a disadvantage, ceteris paribus, when raising external finance. Younger firms are likely to be a riskier prospect since the shorter track record makes it more difficult to judge their quality. Moreover smaller firms often tend to be less diversified, to display greater earnings volatility, and to be more prone to bankruptcy (Titman and Wessels 1988). However, there are also reasons why it might be the case that incentive problems are more severe for firms in which insiders own a smaller proportion of the firm and outside ownership is more dispersed. Since size may proxy for ownership structure, there is some ambiguity in assessing the effect of size on agency cost. Finally, it is intuitively more probable that firms in declining sectors may face financial distress. The second-hand market for capital goods is likely to be less active, the liquidation value of assets to be smaller, and, therefore, the cost of financial trouble greater in this case.

We have assumed so far that positive dividends are being paid because this is what our data suggests happens most of the time. In this case the first-order condition on new share issues implies that $\gamma - 1 - \omega_t + \mu_t^N = 0$, where ω_t is the marginal adverse selection premium firms have to pay when issuing new shares, and μ_t^N is the nonnegativity constraint on new equity issues. If ω_t is independent of V_t^N as in Fazzari, Hubbard, and Petersen (1988), then we need to assume that γ is less than $1 + \omega_t$, otherwise it would pay to finance continuous new dividend distributions by issuing new shares. If the above condition holds, firms will not issue new shares and pay dividends at the same time. In order to provide a satisfactory rationale for an internal solution for dividends and new share issues, it would be necessary to provide an analysis of the signaling role of dividends and of the possibility of tax exhaustion, but this goes beyond the purpose of this paper. The specification of Q models when the various asymmetries of the tax schedule are explicitly modeled is contained in Devereux, Keen, and Schiantarelli (1989), where it is shown that an internal solution for dividends and new share issues can be obtained because the possibility of tax exhaustion reduces the effective value of γ. Alternatively, it must be assumed that personal tax rates vary across investors and that the condition $\gamma = 1 + \omega_t$ determines the marginal investor in the case of an internal solution.

11.5 Interfirm Differences in Financing, Investment and Profitability in the United Kingdom

In this section we discuss how financing, investment, profitability, and other characteristics vary across different types of firms according to size, age, and sector. The results presented here are based on a sample of 720 firms in the U.K. manufacturing sector over the period 1969–86, quoted on the London Stock Exchange. Because of births and deaths and an increase in the number of firms available in 1975, the number of records on each firm varies between 4 and 18; only 89 firms existed for the entire sample period. Data have been obtained from two sources. Accounting data on each firm has been provided by Datastream, and market valuations have been taken from the London Share Price Database (LSPD). These two sources have been merged for each firm in each year to provide the data used in this paper.[6] These firms account for approximately 65% of total investment in manufacturing between 1977 and 1985. The construction of the variables follows that in Blundell et al. (1989). Company investment includes direct purchase of new fixed assets and those acquired through acquisitions. The firm's market value is an average for the three months prior to each accounting year. Replacement cost estimates of the capital stock are estimated using the perpetual inventory method.[7]

The discussion above implied that there are several reasons why one might expect the location of the agency cost function to differ across firms. Given its location, the expectation of the relative effect of financial factors on investment would also depend on their relative investment rates and their cash flow, debt, and other liquid assets relative to their capital stock. In this section we present some evidence on the relative sizes of these ratios and more generally on firms' characteristics according to size, age, and whether they operate in a growing or declining sector.

It is also worth commenting briefly on the difference between these splits (by size, age, and sector) and that used by Fazzari, Hubbard, and Petersen (1988). Fazzari et al. split their sample of firms according to their dividend payout ratios. This was an attempt to identify those firms that were likely to pay no dividends and at the same time did not find it profitable to issue new shares. In the United States, this may be reasonable (Fazzari et al. show that, among their group of firms having a low payout rate, dividends are paid only 33% of the time). However, in the United Kingdom, the vast majority of firms pay dividends every year while some firms also raise external equity finance fairly frequently. Without explicitly modeling why firms pay dividends—for example, because of a possible signaling role (see, e.g., John and Williams

1985; Ambarish, John, and Williams 1987; and Edwards 1987 for a critical discussion)—it is not clear which firms are constrained by their earnings and which are not. For example, if cutting dividends is taken to be a negative signal, firms that have paid high dividends in the past will be forced to maintain a high dividend strategy. Alternatively, following Easterbrook (1984) and Rozeff (1982), it might be argued that firms with a more widespread ownership are required to pay a higher dividend because this implicitly forces them to submit to scrutiny from the market when they raise external funds.

In table 11.1 we present some summary statistics in which each observation on each firm is classified into one of three size categories according to the real value of the capital stock (1980 prices) at the beginning of the preceding period (pK_{t-2}). The observation is classified as small if pK_{t-2} is less than £6 million, medium if pK_{t-2} is between £6 million and £50 million, and large if pK_{t-2} is above £50 million. Note that, as a firm grows, it may move from one

Table 11.1 **Split by Size**

Case 1 $pK_{t-2} < £6m$
Case 2 $£6m < pK_{t-2} < £50m$
Case 3 $pK_{t-2} > £50m$

	Case 1 (%)	Case 2 (%)	Case 3 (%)
Number of observations	2,681	3,966	2,059
Investment/capital stock	13.4	11.1	10.2
Sales/capital stock	318.8	232.9	170.8
Cash flow/capital stock	17.8	13.6	11.4
Profit/capital stock	12.4	8.8	6.6
Dividends/cash flow	23.3	23.8	22.4
Dividends/profit	33.5	36.6	38.7
Investment/total funds[a]	66.4	70.0	78.3
Retentions/total funds	67.9	65.5	68.0
New equity/total funds	13.2	14.8	12.3
Change in long-term debt/total funds	5.7	7.8	13.3
Change in short-term debt/total funds	13.2	11.9	6.5
Change in bank debt/total funds	12.1	10.8	5.2
Long-term debt/market value[b]	7.6	12.5	23.3
Interest paid/(interest + cash flow)	16.6	18.1	20.3
Current assets[c]/capital stock	24.5	20.6	23.2
Average Q^d	−.13	−.19	.11
Standard deviation of real sales growth	16.1	15.4	12.7
Frequency of dividend payments	89.2	94.5	97.5
Frequency of new equity issues	13.6	27.5	49.8

[a]Total funds are the sum of retentions, new equity, and the change in long-term and short-term debt.

[b]Market value is taken as the market value of equity plus the book value of debt.

[c]Current assets comprise inventories and work in progress, financial investments, the stock of cash, and trade debtors less trade creditors, and other short-term liabilities (excluding short-term debt).

[d]Q is defined in equation (4). V_t is measured at the beginning of the period.

group to another. As explained in the next section, we split the sample according to the size of pK_{t-2} in order to minimize problems of endogenous selection in estimation.[8] The table indicates that investment and cash flow, each as a percentage of the end-of-period capital stock, decrease with size. This is particularly true of cash flow, with small firms generating a return of 18% compared to only 11% for large firms. Ceteris paribus, the existence of higher cash flows for small firms makes it less likely that they will face financial constraints. The dividend payout ratio is higher for larger firms, although this appears to be mainly due to the fact that depreciation (the difference between cash flow and profit) represents a higher proportion of cash flow for large firms; the average dividend-to-cash-flow ratio is remarkably constant across the three size categories. The frequency with which dividends are paid increases with size, but even for small firms, however, the average dividend payout ratio is approximately 34% and dividends are paid 89% of the time.

Prima facie evidence that internal sources of finance are preferred to external sources is represented by the fact that investment is financed mainly through retentions, which constitute about 67% of the total sources of funds. Perhaps it is a surprise that the proportion of funds raised from retentions by large firms is almost identical to that raised by small firms. New equity varies between 12% and 15% of total new funds.[9] The frequency of new share issues increases with size. The lower frequency of new equity issues for small firms is consistent with the observation that flotation and underwriting costs are a decreasing function of the value of the issue.

Long-term debt represents a small percentage of investment finance, especially for smaller firms. This suggests that it is expensive for small firms to rely on market debt. Note, however, that the percentage of new finance derived from short-term debt (with maturity of less than one year) is greater for smaller firms. The vast majority of their short-term debt is provided by banks. This indicates that the difficulty of borrowing in the open market may be partly relieved by the ability to borrow from institutions that can more easily monitor the borrower through a continuing relationship. It is not clear, however, that the duration of bank debt matches the requirements imposed by investment projects that will provide a return over a long period of time.

A final piece of interesting evidence from table 11.1 is that the standard deviation of real sales growth falls with size, although this effect is not very large. The slightly higher figure for small firms may be reflected in the relatively high ratio of current assets to the capital stock, in that such firms may find it useful to maintain a sizeable reserve of liquid assets in order to buffer the volatility of sales revenues and to avoid being forced to borrow on unfavorable terms. Moreover, this ratio is one of the indices commonly used by lenders to judge the credit worthiness of potential borrowers. Another indicator of the ability to meet financial obligations is the ratio between interest payments and cash flow, which is smaller for smaller firms. By presenting a healthy liquid asset position firms may be able to reduce the cost of borrowing.

Table 11.2 **Evidence from CBI Industrial Trends Survey of U.K. Manufacturing Companies**

		Size by Number of Employees (%)			
Question Response	Whole Sample	0–199	200–499	500–4,999	More than 5,000
Inadequate net return on proposed investment	39.5	26.3	38.5	41.7	46.5
Shortage of internal finance	21.2	15.4	15.5	8.5	29.2
Inability to raise external finance	2.6	3.0	2.3	2.1	2.9
Cost of finance	8.5	10.6	8.5	8.0	8.4
Uncertainty about demand	46.3	56.7	52.8	48.2	36.9
Shortage of labor (including management & technical staff)	3.1	3.7	3.5	2.4	3.1
Other	2.3	2.0	2.8	2.4	2.4
N.A.	12.2	14.2	9.6	10.3	13.4

Note: This table reflects the average response to the question, "What factors are likely to limit (wholly or partly) your capital expenditure authorizations over the next 12 months?" The question was posed over the period 1981–86 in 24 quarterly surveys.

Table 11.2 presents some independent evidence on the degree to which financial factors are perceived to influence the investment decision of different sizes of firms. The figures are taken from the quarterly survey of U.K. manufacturing industry conducted by the Confederation of British Industry. It indicates that over the period 1981–86. virtually a third of the respondents cited some financial factor as constraining their investment (although it is hard to distinguish the three questions related to financial factors). The most striking feature of the table is. however. the proportion of the largest firms that cited "shortage of internal finance" as a significant constraint on their investment. While the sample of firms in this category is low.[10] this does suggest that very large firms may face financial constraints. The table suggests. however. that slightly less large firms (in the third category) face somewhat lower financial constraints.

Another dimension that has a potential bearing on investment and financing decisions. especially in the presence of asymmetric information, is the firm's age. Although we do not have exact information on each firm's age. we do know when firms went public. In table 11.3. we distinguish between observations on firms that have been quoted for at least 12 years and observations on firms younger than 12 years. In this table we examine only small and medium-size firms (i.e.. pK_{t-2} less than £50 million). Since larger firms are almost exclusively more than 12 years since their first quotation. they would all fall into the "old" category. By concentrating on the remainder. we consider firms which. apart from age, are more nearly alike.

Within this size category. new firms have a higher investment rate and cash flow. The payout ratio is fairly stable across the two categories. New firms have a higher use of retentions and also derive a slightly larger fraction of new funds from new share issues. The higher profitability and investment of the new firms is reflected in a higher value of Q. There is little variation in the standard deviation of sales growth, thus suggesting that sales volatility does not depend to any great extent on firm age.

It was also suggested that the location of the agency cost function, and hence the degree to which companies face financial constraints, depends on the sector in which it is operating. We have therefore also considered the difference between companies in growing and declining sectors, this time conditioning on size by splitting the sample according to whether pK_{t-2} is greater or less than £10 million. (The state of manufacturing industry in the United Kingdom in the 1970s and early 1980s was such that a majority of our sample of firms belonged to sectors that declined over the period considered.) As might be expected, comparing firms of similar size, both investment and profitability are, on average, higher for firms in growing sectors. Again, however, the average dividend payout ratios are very similar across the different categories. Further, no clear pattern emerges concerning the use of different sources of finance, although small firms in growing industries make less use of retention finance (only 59% of total new funds).

Table 11.3 **Split by Size and Age**
Case 1 $pK_{t-2} < £50m$; less than 12 years since first quotation
Case 2 $pK_{t-2} < £50m$; more than 12 years since first quotation

	Case 1	Case 2
Number of observations	773	5,874
Investment/capital stock	14.4	11.0
Sales/capital stock	282.5	238.0
Cash flow/capital stock	18.0	13.6
Profit/capital stock	12.3	8.9
Dividends/cash flow	23.6	23.7
Dividends/profit	34.5	36.4
Investment/total funds	72.3	69.2
Retentions/total funds	69.0	65.5
New equity/total funds	15.3	14.5
Change in long-term debt/total funds	5.9	7.7
Change in short-term debt/total funds	9.8	12.3
Change in bank debt/total funds	9.3	11.1
Long-term debt/market value	10.1	12.2
Interest paid/(interest + cash flow)	17.4	18.0
Current assets/capital stock	13.2	21.8
Average Q	.81	−.30
Standard deviation of real sales growth	17.1	15.6
Frequency of dividend payments	95.5	92.0
Frequency of new equity issues	24.1	21.6

Notes: For information on variables, see table 11.1.

11.6 Empirical Results

What does the empirical evidence say about the role of financial factors in investment decisions for U.K. firms? We start our discussion from the results obtained from estimating equation (3) for the entire sample. We wish to allow for the possibility of time-specific (α_t) and firm-specific (α_i) effects. Introducing the subscript i to distinguish companies. we therefore wish to estimate

$$(6)\qquad \left(\frac{I}{K}\right)_{it} = \beta_0 + \beta_1 Q_{it} + \beta_2\left(\frac{X}{pK}\right)_{it} + \beta_3\left(\frac{B}{pK}\right)_{it} + \beta_4\left(\frac{L}{pK}\right)_{it} + \alpha_i + \alpha_t + v_{it}$$

The stochastic term. v_{it}. arises from disturbances to the adjustment cost function. as in the standard Q model. There is nothing in the theory that restricts this term to be an innovation error. and. indeed. related research estimating the Q model on similar data has suggested that v_{it} follows an AR(1) process (Blundell et al. 1989). To allow for this possibility. lagged values of the dependent variable and of each regressor are included in the equation (although we estimate the model without imposing the common factor restriction). The lagged values may. of course. also reflect the ambiguities involved in choosing the timing of the various variables.

The model has been estimated in first differences to allow for firm-specific. time-invariant effects and an instrumental variable procedure is used to allow for the endogeneity of the regressors.[11] This endogeneity arises because current cash flow. debt. current assets. Q, and investment may all be simultaneously determined (although Q, unlike the other variables. is constructed by dating it at the beginning of the period). In addition. care must be taken to allow for the possibility of measurement error. particularly in Q. Not only are contemporaneous values of these variables invalid instruments. but first differencing introduces the correlation between. for example. Q_{t-1} and v_{t-1} into the equation. In the absence of serial correlation in v_{it}. however. further lags of each of the regressors are valid instruments. Thus. in the third period. variables dated $t = 1$ may be used as instruments in the differenced equation (as well as Q_{i2} if it is uncorrelated with v_{i2}). Similarly. in the fourth period. variables dated $t = 1$ and $t = 2$ are valid instruments. Since this gives more instruments in later periods. and since v_{it} may be heteroscedastic across companies. we use an application of Hansen's (1982) generalized method of moments estimator. However. computing restrictions force us to restrict the instrument set.[12] Below. we denote the instrument set used in the form $Q(n.m)$. where n indicates that the latest lag used is dated $t - n$. and m indicates the number of lags used.[13]

In column 1 of table 11.4 we present the estimated coefficients for the equation containing. in addition to Q and lagged investment. both flow and stock

Table 11.4 The Full Sample

	Period 1972–86 720 Companies, 6,546 observations		
Dependent Variable $\Delta(I/K)_t$	1	2	3
$\Delta(I/K)_{t-1}$	.1896	.1896	.1907
	(.0306)	(.0286)	(.0284)
ΔQ_t	.0180	.0166	.0158
	(.0051)	(.0079)	(.0074)
ΔQ_{t-1}	−.0044	−.0039	−.0036
	(.0019)	(.0025)	(.0023)
$\Delta(X/pK)_t$	.1168	−.0086	.0481
	(.0788)	(.1494)	(.1180)
$\Delta(X/pK)_{t-1}$	.1584	.2309	.2179
	(.0582)	(.0894)	(.0798)
$\Delta(B/pK)_t$	−.0772	—	—
	(.0300)		
$\Delta(B/pK)_{t-1}$	.0581	—	—
	(.0418)		
$\Delta(L/pK)_t$	−.0149	—	—
	(.0130)		
$\Delta(L/pK)_{t-1}$	.0153	—	—
	(.0138)		
$\Delta(Y/pK)_t$	M	—	−.0059
			(.0043)
$\Delta(Y/pK)_{t-1}$	—	—	.0023
			(.0033)
$m2$	−1.26	−1.17	−1.21
Sargan	59.0 (55)	97.7 (70)	95.5 (68)
W	52.1 (15)	49.5 (15)	51.1 (15)
Instruments	$Q(2,2)$,$CF/pK(2,1)$ $B/pK(2,1)$, I/K_{t-2},I/K_{t-3}, L/pK_{t-2},L/pK_{t-3}	$I/K(2,1)$, $Q(2,2)$ $CF/pK(2,1)$ $Y/pK(2,1)$	$I/K(2,1)$,$Q(2,2)$ $CF/pK(2,1)$ $Y/pK(2,1)$

Note: Time dummies are included in all equations. Asymptotic standard errors are reported in parentheses. Standard errors and test statistics are asymptotically robust to heteroscedasticity across companies. The notation $m2$ is a test for second-order serial correlation in the residuals, asymptotically distributed as $N(0,1)$ under the null of no serial correlation (see Arellano and Bond 1988). The Sargan statistic is a test of the over-identifying restrictions, asymptotically distributed as $\chi^2(k)$. Here W is a Wald test of the joint significance of the time dummies, asymptotically distributed as $\chi^2(k)$, under the null of no significance. The instrument sets are explained in the text.

measures of liquidity and the stock of debt.[14] Time dummies are included as regressors and instruments in all equations. The results suggest that contemporaneous Q is a significant determinant of investment although, as in most other empirical studies, the size of its coefficient is small. Cash flow, especially dated $t-1$, plays an important role with large coefficients. The coefficient on contemporaneous debt is negative and significant, as one would expect if an increase in cash flow decreases the marginal agency cost of debt, so that $A_{X,B/X} < 0$ (see [5]). The stock of liquid assets does not play a significant role in this equation. Dropping liquid assets from the model in column 1 has very little effect on the other terms in the equation.

These results are generally robust to variations in the instrument set. The equation does not exhibit second-order serial correlation (see the $m2$ statistic), which would invalidate the instrument set. Moreover, the Sargan test of overidentifying restrictions suggests that the instruments are not correlated with the error term. If Q_{t-1} is included in the instrument set, the coefficient on contemporaneous Q falls, which is consistent with the possibility that downward bias due to measurement error in Q outweighs any upward bias due to the possible endogeneity of Q.[15] This result is also found when the same comparison is made for the other equations presented below, and so we generally exclude Q_{t-1} from the instrument set.

The positive effect of the lagged investment rate and the negative coefficient on the lagged Q term are consistent with an AR(1) error term in the underlying equation. However, the positive coefficients on both the cash flow terms is inconsistent with this explanation of the dynamic structure. (Replacing $[X/pK]_t$ with $[X/pK]_{t-2}$ provides a result consistent with the AR[1] process, although this would imply that lagged cash flow, not current cash flow, should be in the specification in eq. [3].) This suggests that the timing of the impact of cash flow in investment is more complex than suggested by the model in Section 11.4. Intuitively, the significance of lagged cash flow may be explained if external investors may observe only cash flow in the previous period or, more generally, may judge the firm's credit worthiness using a weighted average of past cash flows.[16]

In column 2 of table 11.4 we explore what happens when debt and liquid assets are excluded from the model (debt is rarely significant in the subsamples of the data examined below, mainly due to the fact that less data is available). The positive effect of contemporaneous cash flow disappears in the absence of the negative effect of contemporaneous debt, while lagged cash flow becomes more important. The coefficient on current Q falls slightly.

In column 3, current and lagged output, Y, as a proportion of the replacement value of the capital stock are added to this specification (contemporaneous output is not significant). Their coefficients are neither individually nor jointly significant. However, note that the negative coefficient on current output is consistent with the presence of imperfect competition, which introduces an additional wedge between marginal and average Q, which depends on the present value of current and future output.[17] The wedge captures the loss of monopoly profits due to the decrease in price associated with the additional output produced by new investment. Adding output to the equation to some extent proxies for the wedge, and therefore we would expect a negative coefficient.[18] We explore this issue further below for different subsamples of the data.

The presence of output in the equation has little effect on the coefficient of lagged cash flow. Its remaining significance suggests that even if cash flow is to some extent proxying for demand, this is not the main reason for its importance. The principal model investigated below is a parsimonious version of column 2 of table 11.4, dropping lagged Q and current cash flow (which are individually and jointly insignificant). The size and significance of the other variables are virtually unchanged when these two terms are omitted.

One reason for the significance of cash flow is that it may be a better proxy for market fundamentals than the market value of the firm, and entrepreneurs may respond only to fundamentals (Blanchard, Rhee, and Summers 1988). In this case one would expect that during periods of potential speculative bubbles or fads in the stock market, the coefficient for Q and cash flow should be different, compared with other periods. In particular one may expect that Q matters less relative to cash flow in such periods. It is obviously difficult to identify unambiguously when bubbles or fads caused share prices to be a poor reflection of fundamentals. During the years covered by our estimation, the years between 1981 and 1986 are possible candidates; average price–earnings ratios have been consistently higher from 1981 onward than over the previous 10 years. While this may, of course, simply reflect more optimistic expectations, this may also reflect the existence of a bubble.

We have therefore reestimated the specification used below, for example in table 11.5, allowing all of the slope coefficients to differ between the two subperiods. However, there is no strong evidence of a structural break. The Wald test statistic for the joint significance of the three additional terms (each variable interacted with a dummy equal to 1 for the period 1981–86 and 0 otherwise) is 6.83 (compared with a critical value of 7.81 at the 5% significance level). In addition, the coefficient on lagged cash flow for the whole period was 0.2951 (with standard error of 0.0462), while that for the additional variable lagged cash flow from 1981 to 1986 only was -0.0982 (with standard error of 0.0607). If Q_{t-1} is included in the instrument set, the three additional terms become jointly significant (with a Wald statistic of 15.3). The same pattern arises for the cash-flow terms, and additionally in this case, the coefficient on Q from 1981 to 1986 only is positive and significant. Any support for a structural break that might be found in these results would therefore be in the opposite direction to what would be expected if cash flow were merely proxying for market fundamentals. Rather, it seems that in the relative boom years of the 1980s firms were simply less financially constrained and hence cash flow was less important. The asymmetric effect of cash flow on investment during booms and recessions is emphasised by Gertler and Hubbard (1988). Of course, it may be that cash flow proxies both for market fundamentals and financial constraints, but that the change in the latter dominates in the 1980s. This is an issue that deserves further investigation. However, these initial results suggest that fads and bubbles are not the key explanation as to why cash flow is significantly related to investment.

The arguments summarized in the previous section suggest that cash flow and other financial variables may have a differential impact across different types of firms. In table 11.5 we present the results on the effect of cash flow for firms of three different sizes (small, medium, and large). We also consider "very large" firms (which are a subset of the group of large firms). Note that observations are classified according to the size of the capital stock at the end of time $t - 2$, pK_{t-2}. Under the assumption that the error term in the levels equation is not serially correlated, pK_{t-2} is predetermined with respect to the error term in the differenced equation. Current assets were not significant when added to the various equations. In addition, current cash flow and further lags of cash flow and Q were generally insignificant when added to the equations presented.

Consider, first, cases 1, 2, and 3 in table 11.5. The coefficient on cash flow is significant for all classes of firms. Perhaps surprisingly, it is greater for large firms, although there is not a statistically significant difference between the coefficients for large and small firms at normal significance levels (the t-statistic for the significance of the difference between the two coefficients is 1.13).[19] The coefficient and the significance of current Q increase across the size categories; for small firms Q appears to have no impact on investment, while for large firms the coefficient on Q is much greater. Given the increasing coefficient on cash flow as size increases, we also consider whether the impact of cash flow for large firms is dominated by very large firms. The results shown in case 4 show that this may be the case; although the coefficient on cash flow for very large firms is less precisely determined (due to fewer obser-

Table 11.5 **Split by Size**
Case 1 $pK_{t-2} < £6m$
Case 2 $£6m < pK_{t-2} < £50m$
Case 3 $pK_{t-2} > £50m$
Case 4 $pK_{t-2} > £100m$

Dependent Variable $\Delta(I/K)_t$	Case 1	Case 2	Case 3	Case 4
Number of firms	311	403	164	112
Number of observations	1,709	3,111	1,726	1,140
$\Delta(I/K)_{t-1}$	.1723	.1550	.1056	.1032
	(.0485)	(.0355)	(.0493)	(.0480)
ΔQ_t	.0011	.0144	.0188	.0085
	(.0052)	(.0082)	(.0101)	(.0058)
$\Delta(X/pK)_{t-1}$	.2275	.2263	.3163	.4050
	(.0413)	(.0385)	(.0667)	(.1113)
$m2$	−2.14	−.52	−.18	.03
W	67.3 (15)	67.1 (15)	38.0 (15)	59.7 (15)
Sargan	82.1 (72)	89.4 (72)	85.0 (72)	73.8 (72)
Instruments	$I/K(2,1)$, $Q(2,2)$, $CF/pK(2,1)$, $Y/pK(2,1)$			

Note: See notes to table 11.4.

vations) the significance of the difference between it and that for small firms is slightly higher (with a t-statistic of 1.50).

These qualitative results are invariant to alternative instrument sets. However, the significance of both the Q and cash flow does vary with the instrument set. In particular, if Q_{t-1} is included in the instrument set, current Q is statistically significant for medium, large, and very large firms although the estimated coefficients are slightly lower. In addition, the differences between the cash-flow coefficients are more significant (with t-statistics of 1.68 for the difference between small and large firms and 1.88 for the difference between small and very large firms).

With one main exception, adding other regressors has little impact on the coefficients and standard errors presented in table 11.5. The exception occurs when current output is added to the model for large firms. The coefficient on current output for large firms is -0.0106 with a standard error of 0.0026. Its negative sign is again consistent with the possibility that output is reflecting the existence of imperfect competition since large firms are more likely to be in a position to exploit the benefits of monopolistic competition. The coefficient on current cash flow for large firms increases substantially when current output is included, although it is less precisely estimated. Current debt also has a negative sign but is not significant when added to the models in table 11.5. Adding debt tends to increase the difference in the coefficients on cash flow between case 1 and case 3 firms, although their standard errors also increase.

In the context of the model sketched in Section 11.4, the size of the coefficient on cash flow for large firms cannot be accounted for by a higher investment rate of large firms (see [5]), because it is, in fact, lower. It could be explained by the lower cash flow/capital ratio that characterizes larger firms, if the coefficient of cash flow decreases with this ratio. It is easy to find parameterizations of the agency cost function that yield this result.[20] This factor may be dominant since differences in the investment rate are not very large and neither is the difference in the riskiness as measured by the variance of sales. It is also possible that the differential according to size may capture industry effects. Finally, it is possible that, ceteris paribus, agency costs may be more severe when insiders effectively controlling the firm hold a lower fraction of the equity and/or outside equity holdings are more dispersed. Size may proxy for the effect of these factors on the severity of the incentive problems.

Two criticisms might be made with regard to splitting firms according to the replacement cost value of the capital stock two periods ago. One is that there may remain some endogeneity introduced by serial correlation in the error term (although we do not find such correlation). The second is that whatever effects size is proxying for, an alternative would be to split by the size of a firm relative to the size of other firms in the industry in which that firm operates. Thus a "small" firm overall may seem larger relative to other firms in its own industry. To meet these possible criticisms, we first split firms according to their initial size (that is, their size when they first entered the data base). Of course, this takes no account of the rate of growth of a firm since it entered the data base, and, possibly as a result, there is much less variation in the value of the cash-flow coefficient between different size classes of firms measured by initial size. However, in table 11.6, we present the results of splitting firms according to their initial size relative to that of other firms in their industry that are also in the data base. Thus, case 1 firms are among the smallest 75% of firms in their industry measured by initial size and case 2 firms are among the largest 25%. It is clear from the table that the results concerning cash flow are similar to those in table 11.5 (indeed the size and significance of the difference across the two categories is greater in table 11.6; the t-statistic on the difference between the two cash-flow coefficients is 1.84). By contrast, however, Q appears more important for the smaller firms. This latter result may be partly due to grouping together all "nonlarge" firms in the first column.

While we do not have any data on ownership patterns, we can control for industry. An interesting distinction, as suggested above, is between growing and declining sectors. Table 11.7 contains the results of the size/sector split (using only two categories for size). Due to the small number of observations in some of the categories, parameters are estimated with less precision than in other tables. The perhaps surprising result from table 11.7 is that the coefficient on cash flow is greater for firms operating in growing sectors. This is true even if the long-run impact of cash flow is considered. This table also mirrors the result that cash flow is more important for large firms, with the largest coefficient being for large firms in growing sectors. This result is not

Table 11.6 **Split by Initial Size Relative to Distribution of Industry Initial Size**
Case 1 pK_0 within smallest 75% of firms in the same industry
Case 2 pK_0 within largest 25% of firms in the same industry

Dependent Variable $\Delta(I/K)_t$	Case 1	Case 2
Number of firms	4,530	2,016
Number of observations	541	179
$\Delta(I/K)_{t-1}$	.1741	.1782
	(.0325)	(.0546)
ΔQ_t	.0130	.0060
	(.0082)	(.0032)
$\Delta(X/pK)_{t-1}$	.2303	.3613
	(.0293)	(.0648)
$m2$	−1.67	−.33
W	96.9 (15)	38.5 (15)
Sargan	102.0 (72)	85.1 (72)
Instruments	$I/K(2,1)$, $Q(2,2)$, $CF/pK(2,1)$, $Y/pK(2,1)$	

Note: See notes to table 11.4.

Table 11.7 **Split by Size and Sector**
Case 1 $pK_{t-2} < £10m$; growing sectors
Case 2 $pK_{t-2} < £10m$; declining sectors
Case 3 $pK_{t-2} > £10m$; growing sectors
Case 4 $pK_{t-2} > £10m$; declining sectors

Dependent Variable $\Delta(I/K)_t$	Case 1	Case 2	Case 3	Case 4
Number of firms	157	298	132	279
Number of observations	859	1,775	1,356	2,556
$\Delta(I/K)_{t-1}$	.2222	.1246	.0614	.1149
	(.0674)	(.0454)	(.0613)	(.0413)
ΔQ_t	.0086	.0142	.0299	.0061
	(.0080)	(.0056)	(.0145)	(.0030)
$\Delta(X/pK)_{t-1}$	.2719	.1786	.3234	.2055
	(.0648)	(.0400)	(.0683)	(.0433)
$m2$	−3.05	−1.24	−.66	.02
W	39.8 (15)	55.8 (15)	30.9 (15)	48.5 (15)
Sargan	67.1 (72)	85.8 (72)	82.2 (72)	89.3 (72)
Instruments	$I/K(2,1)$, $Q(2,2)$, $CF/pK(2,1)$, $Y/pK(2,1)$			

Note: See notes to table 11.4. Growing sectors are chemicals and man-made fibers; electrical and instrument engineering; and food, drink, and tobacco. Declining sectors are metals and metal goods; other minerals and mineral products; mechanical engineering; motor vehicles, parts, and other transport equipment; textiles, clothing, leather, and footwear; and other industries.

sensitive to the instrument set used. One explanation for this effect may be that the lower investment rate of firms in declining sectors dominates empirically their lower cash flow and their higher agency costs, which, ceteris paribus, would be expected to arise. The table indicates that the impact of Q is mixed: among small firms it is more important for firms in declining sectors but among large firms it is more important for firms in growing sectors.

The final issue we wish to explore is the effect of age on the relevance of cash flow. In table 11.8 we report the results obtained when, excluding large firms, we distingnish between firms that have been quoted for more or less than 12 years. Twelve years may seem a rather long time, but it is imposed by the necessity of having enough observations in the "new" firms category for the purposes of estimation. The results suggest that cash flow is somewhat more important for new firms, although the differences between the two categories are not large. Once again, it should be noted that the category of new firms is very small, and that the variables consequently tend to be less significant.

11.7 Conclusions

The results discussed in this paper suggest that, in all cases, cash flow is significantly associated with investment. Stock measures of liquidity do not play an important empirical role. The stock of debt does appear to have a

Table 11.8 **Split by Size and Age**
Case 1 $pK_{t-2} < £50m$; less than 12 years since first quotation
Case 2 $pK_{t-2} < £50m$; more than 12 years since first quotation

Dependent Variable $\Delta(I/K)_t$	Case 1	Case 2
Number of firms	99	574
Number of observations	450	4,370
$\Delta(I/K)_{t-1}$	.0935	.1939
	(.0610)	(.0342)
ΔQ_t	.0122	.0095
	(.0099)	(.0066)
$\Delta(X/pK)_{t-1}$	.2720	.2242
	(.0662)	(.0302)
$m2$	−1.57	−.97
W	36.7 (15)	88.4 (15)
Sargan	48.3 (44)	100.7 (72)
Instruments	$(I/K)_{t-2}$, $(I/K)_{t-3}$, $Q(2,1)$, $CF/pK(2,1)$, $Y/pK(2,1)$	$I/K(2,1)$, $Q(2,2)$, $CF/pK(2,1)$, $Y/pK(2,1)$

Note: See notes to table 11.4.

negative impact on investment, although the significance of this term depends on the size of the sample. The performance of Q is mixed. While it plays a significant role in the full sample, there are subsamples, typically of small firms, in which it does not appear to have an independent effect on investment. The results for the full sample over different time periods suggest that the significance of cash flow is not due solely to the fact that, in proxying for demand, it is a better measure of fundamentals than Q, nor simply that it contains new information not captured by beginning-of-period Q, although more research is needed on this issue.

Cash flow does appear to differ across firms in the magnitude of its impact on investment. In particular, it appears to play a more important role for large firms than for small firms. While this may be surprising at first sight, there are several reasons why this effect might be observed. For example, it may reflect the fact that large firms tend to have a lower relative cash flow. In addition, it may reflect the possibility that large firms have a more diverse ownership structure, which tends to increase agency costs. Given size, the effect of cash flow tends to be larger for firms in growing sectors, contrary to what one would expect since collateralizable net worth is likely to be larger in this case and the risk of bankruptcy lower. However, firms in growing sectors need to finance a higher rate of investment. Finally, when firms are classified according to age, it appears that cash flow matters somewhat more for newer firms, as would be expected since information asymmetries are likely to be larger for such firms and they need to finance a higher investment rate.

Our results suggest that capital market imperfections should be an important ingredient of any extension to or reformulation of the adjustment cost model of investment. However, the mixed performance of Q suggests that such extensions should be pursued in future work.[21]

Appendix

The firm maximizes the market value of the shares of existing shareholders, V_t:

$$\text{(A1)} \qquad V_t = E_t \sum_{j=t}^{\infty} \left(\frac{1}{1 + R/(1-z)} \right)^{j+1-t} \{\gamma D_j - V_j^N (1 + \omega_j)\},$$

where D_j denotes dividends, V_j^N new shares issued, ω_j the sample selection premium, all in period j, and $\gamma = (1 - m)/(1 - z)(1 - c)$, with m denoting the tax rate on dividends, z the tax rate on capital gains, and c the rate of imputation. Here R is the market rate of return on equity, assumed to be constant for simplicity.

The maximization is subject to the definition of sources and uses

$$\text{(A2)} \qquad (1 - \tau) p_t^y \Pi(K_t, I_t) - A(X_t, B_t, L_t, p_t K_t) + V_t^N + B_{t+1}$$
$$+ L_t[1 + (1 - \tau) i^L] = D_t + p_t I_t + [1 + i(1 - \tau)] B_t + L_{t+1},$$

where τ is the corporate tax rate, p_t^y the price of output, p_t the price of investment goods, $p_t^y \Pi(\mathrm{t})$ real revenues net of variable costs, K_t capital stock, $A(t)$ agency costs of debt, B_t debt, L_t liquid assets, all in period t, i the rate of interest on debt, and i^L the rate of interest on liquid assets. For ease of notation, we omit depreciation allowances; these are included, however, in the empirical work. Cash flow, denoted X_t, is defined as

$$X_t = (1 - \tau)\Pi(\mathrm{t}) - [1 + i(1 - \tau)] B_t + [1 + i^L(1 - \tau)] L_t.$$

The capital accumulation equation is

$$\text{(A3)} \qquad K_t = (1 - \delta) K_{t-1} + I_t$$

and the nonnegativity conditions are $V_t^N \geq 0$ and $D_t \geq 0$.

The first-order conditions are:

$$\text{(A4)} \qquad (\gamma + \mu_t^D)[(1 - A_X[t])(1 - \tau) p_t^y \Pi_I(t) - p_t] + \lambda_t^K = 0,$$

$$\text{(A5)} \qquad (\gamma + \mu_t^D)[(1 - A_X[t])(1 - \tau) p_t^y \Pi_K(t) - p_t A_K(t)]$$
$$- \lambda_t^K + \frac{1 - \delta}{1 + R/(1 - z)} \lambda_{t+1}^K = 0,$$

$$\text{(A6)} \qquad \gamma + \mu_t^D - 1 - \omega_t + \mu_t^N = 0,$$

(A7) $$(\gamma + \mu_t^D) + \frac{(\gamma + \mu_{t+1}^D)}{1 + R/(1 - z)}[-(1 - A_X[t+1]) (1 + [1 - \tau]i) - A_B(t+1)] = 0,$$

(A8) $$(\gamma + \mu_t^D) + \frac{(\gamma + \mu_{t+1}^D)}{1 + R/(1 - z)}[(1 - A_X[t + 1]) (1 + [1 - \tau]i^L) + A_L(t+1)] = 0.$$

Also:

(A9) $$\lambda_t^B + (\gamma + \mu_t^D)[(1 - A_X[t])(1 + [1 - \tau]i) + A_B(t)] = 0$$

(A10) $$\lambda_t^L + (\gamma + \mu_t^D)[(1 - A_X[t])(1 + [1 - \tau]i^L) + A_L(t)] = 0.$$

λ's denote the multipliers associated with the state variables and μ_t^D and μ_t^N the multipliers associated with the nonnegativity condition for D_t and V_t^N. Equations (A4) to (A10), together with the complementary slackness conditions, summarize the conditions for an optimum.

If we assume that the adjustment cost function is separable and has the form

$$\frac{b}{2}\left[\left(\frac{I}{K}\right)_t - c\right]^2 K_t,$$

equation (A4) yields (1) in the main text when $D_t > 0$ so that $\mu_t^D = 0$.

In order to obtain the relationship between the marginal and average value of the capital stock, equation (2) in the main text, multiply (A4) by I_t, (A5) by K_t, (A6) by V_t^N, (A7) by B_{t+1}, (A8) by L_{t+1}, (A9) by B_t, (A10) by L_t, and add them together. Solve the resulting difference equation forward and note that (A7) and (A9) imply that

$$\lambda_{t+1}^B = -(\gamma + \mu_t^D)[1 + R/(1 - z)],$$

and that (A8) and (A10) imply that

$$\lambda_{t+1}^L = (\gamma + \mu_t^D)[1 + R/(1 - z)].$$

This yields equation (2) in the main text.

Notes

1. However, the possibility of negative profit, combined with corporate tax asymmetries, reduces the effective corporate tax rate because there may not exist taxable profits against which to offset an interest payment. This reduces the tax advantage of debt (see DeAngelo and Masulis 1980; Auerbach 1986; and Mayer 1986).

2. For example, typical transaction costs in raising £5 million would be around £250,000, compared with only £500,000 for raising £50 million.

3. The existence of a high allowance for capital gains results in a zero marginal tax

rate for investors earning less than about £6,000 per year in the form of capital gains. One should, in addition, consider the possibility that firms may not be able to offset their advance corporation tax against the mainstream corporation tax. This implies that the effective rate of imputation is smaller than the statutory rate, making new share issues less attractive (Keen and Schiantarelli 1988).

4. See also Steigum (1983) and Bemstein and Nadiri (1986) in which the cost of borrowing is made an increasing function of the debt/equity ratio.

5. Edwards and Keen (1985) discuss what happens when dividends are tax favored and a maximum limit is imposed on their distribution, as is the case in the United Kingdom.

6. The LSPD data is needed to calculate Tobin's Q.

7. Further details are available from the authors on request.

8. Splitting by payout behavior is more open to criticism from this point of view. In order to allow for any distortion to these results arising from measurement error in K, a similar split was performed using the real value of sales two periods earlier as a measure of size. The results were very similar.

9. Mayer (1987, 1988) claims that the proportion of funds raised from new share issues is somewhat lower, although our figures are in line with official statistics (DTI Business Monitor, MA3).

10. Between 25 and 60 out of a sample of around 1,250.

11. Related research (Blundell et al. 1989) has indicated that the presence of firm-specific effects can lead to biased estimated coefficients when the model is estimated in its levels form. In addition, the presence of the lagged dependent variable in the more general equation makes the within-groups estimator inconsistent for dynamic models with small T (Nickell 1981).

12. We have used GAUSS 1986, version 1.49B, in which the instrument set must be restricted to 90 instruments. Thanks are due to Manuel Arellano and Stephen Bond for allowing the use of their GAUSS programs in this work.

13. For $m = 1$, the GMM instrument set differs from simply using Q_{t-n} essentially by allowing the reduced-form coefficient to vary over time.

14. We have experimented with alternative empirical measures for γ. The results are very similar whatever measure is used. The results are also not sensitive to the inclusion of the discount factor, R, in the definition of Q_t. In the tables we report the results obtained when γ and the discount factor are set equal to one.

15. In principle, including Q_{t-2} in the instrument set may also introduce measurement error since it also appears as a regressor in the differenced equation, although in later tables the first-differenced Q_{t-1} is omitted since it is not significant for subsamples of the data. This issue has been explored in detail by Blundell et al. (1989) on the same data set, and our choice of instrument set is consistent with their results.

16. This would require the inclusion of X_{t-1} and further lags in the agency cost function described in Section 11.4.

17. More precisely, omitting debt, liquid assets, and taxes, it can be shown that

$$\lambda_t^K = \frac{\left(1 + \frac{R}{1 - z}\right)\left\{V_t - \sum_{i=1}^{\infty} \frac{1}{\epsilon_{t+i}}\left(1 + \frac{R}{1 - z}\right)^{-i} p_{t+i}^{y} Y_{t+i}\right\}}{(1 - \delta)K_{t-1}},$$

where ϵ_{t+i} is the elasticity of demand.

18. However, if the equation is estimated in a quasi-differenced form, as suggested by Schiantarelli and Georgoutsos (1990) and Galeotti and Schiantarelli (1988), the contemporaneous investment rate, given "scaled" past investment, should be positively

related to $(Y/K)_{t-1}$. When this variable is added to our specification alone, it is rarely significant. This issue deserves additional investigation.

19. We need to test the hypothesis that the difference between the cash-flow coefficients equals zero. On the assumption that the error terms are independent across the two categories, the appropriate standard error is simply the square root of the sum of the squares of the two standard errors on the two coefficients. This allows a simple t-test to be performed on the difference between the coefficients.

20. This would be the case, for example, if, ignoring liquid assets

$$A = \{-a(X/K)^{\alpha} + b\,(B/K)^{\beta}\}K,$$

where $0 < \alpha < 1$, or if

$$A = (X/K)^{\alpha}(B/K)^{\beta}K,$$

where $\alpha < 0$.

21. For example, see Chirinko (1984) and Hayashi and Inoue (1988) for Q models with multiple capital inputs, Galeotti and Schiantarelli (1988) for a Q model with imperfect competition and labor as a quasi-fixed factor, and Bond and Meghir (1989) for an adjustment cost model that avoids the use of stock market values and parameterization of the gross production function.

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